A study on the shade tolerance of *Muehlewbeckia complera*

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Abstract: *Muehlewbeckia complera* was introduced to China in 2002 as indoor-hanging ornamental foliage plant. The experiment of the shade tolerance for this species was carried out in different light intensities (0.14-946.00 μmol · m^{-2} · s^{-1}). After 40 days in experimental areas, leaf photosynthentic characteristics indexes of *M. complera* in different photosynthesis active radiation (PAR) were measured with LI-COR6400 apparatus, such as the light compensation point, light saturation point, and maximum net photosynthesis rate, at the same time, the increments of total leaf area and leaf amount were measured. The results showed that the optimum light intensity range for *M. complera* was from 9.26 μmol · m^{-2} · s^{-1} to 569.00 μmol · m^{-2} · s^{-1} (463-28150 lx, relative humidity (RH) for 46-60%, temperature at 16-22 °C). Under this condition, leaf photosynthetic efficiency was tiptop. Although *M. complera* belonged to the moderate sun-adaptation plant species, the plant growth was inhibited when PAR increased to the level of 569.000 μmol · m^{-2} · s^{-1} or above. *M. complera* could sprout new leaves in photosynthesis active radiation of 0.16-19.22 μmol·m^{-2}·s^{-1} (8-961 lx), or 10 μmol · m^{-2} · s^{-1} for above 6 h.

Keywords: *Muehlewbeckia complera*; Shade tolerance; Cultivation; Photosynthesis
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Introduction

Muehlewbeckia complera is indoor-hanging ornamental foliage plant and has highly admired value. Its blade profile is ellipse with brightness and branches are dark brown and similar to the elegant hair. It was introduced to China in 2002 but no quantitative data was offered by the dealer. In practice, under relatively low irradiance or strong light, leaves of *M. complera* turned into yellow and branch had excessive vegetative growth, being easily infected by diseases, as a result, its admired value was declined. In all literatures about *Muehlewbeckia complera,* there were few concretely quantitative data about its favorite light intensity.

In different rooms with different directions, the light distribution and hours of sunshine were different. Even at the different locations in the same room, the light distribution and time of sunshine were also different. In the rooms facing to the south, east, or west, the three regions with different light intensity could be plotted out: 10000-80000 lx (suitable for ornamental foliage plant of favorite sunshine), 5000 lx (suitable for ornamental foliage plant of favorite partial shade), less than 5000 lx (suitable for ornamental foliage plant of favorite shade), (Ye 2001). In the room of exposing to the north, there is not a region of light intensity for 10000-80000 lx. According to the measured diurnal variation of illumination in different locations, the authors selected three representative regions to culture *M. complera*. Based on the photosynthetic characters of *M. complera* in different illuminated regions, the light intensities at different distances from windows were measured, and the favorite light conditions of the plant were determined, with an aim provide a scientific foundation for itsindoor cultivation.

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Materials and methods

Materials and environmental conditions

The experiment was conducted with stem-planting seedling of introduced *Muehlewbeckia complera* in April and May, 2003. Five representative experimental areas (area A, B, C, D and E) were selected in two rooms at the different distances from southing, northing, and easting windows on the 5th floor of a building in Harbin. Area A, B and C were set in first room (windows southing), area D and E were set in second room (northing and easting windows, respectively). Area A, B and C were at the distances of 0.7 m, 3.0 m and 5.0 m from southing windows, respectively. Area D was at the distances of 2.7 m from a northing window and 2.8 m from an easting window. Area E was at the distance of 0.3 m from a northing window. The diurnal changes of light intensity, temperature, and humility of the 5 areas in two rooms were recorded.

Drawing of photosynthesis-light response curves

After 40 days in experimental areas, the photosynthesis indexes were measured by using LI-COR-6400 under different light intensities (produced by artificial light source), (Bai *et al.* 1999). The measurement was repeated twice. The authors acquired the light compensation point, light saturation point, and maximum net photosynthesis rate through the methods of counting light compensation point, light saturation point photosynthesis and the method of

imitating photosynthesis-light response curve (Wang 1996; Wu 2003; Zhang *et al.* 1997; Zhang *et al.* 2002; Dubas *et al.* 1980; Yue *et al.* 2003; Abrams *et al.* 1994; Wu 2003).

Measuring plant growth indexes

The total leaf area was measured by using LI-3000A leaf area apparatus for the leaves growing on randomly selected branches. After 20 days, all indexes were re-measured, and the leaf area increment was calculated.

Results and analysis

Environmental factors in the experimental area

The diurnal light intensity, temperature, and humility in the 5 experimental areas were recoded in order to acquire the correlation between the environmental factors and the seedling growth (Table 1 and Table 2).

The temperature and relative humility in the 5 areas were 16-28 °C and 44%-64%, respectively. They represented the optimum temperature and humility ranges for the highest growth of the plant. The light intensity was 0.16-946.00 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (8-47300 lx). The results showed that the variations of temperature and humility were not relatively obvious, but light intensity had an obvious variation in the 5 areas (Table 1).

The maximum light intensity in area A, B, and C occurred at 14:00 p.m. (Table 2). The light intensity in area A was strong. Its maximum light intensity was 378-927 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (18900-46340 lx), which was higher than that of other treatment areas, and its illuminated duration was about 4 h, which was 2-4 h longer than that of other treatment areas. Area B belongs to the bright area, the illuminated duration of 30 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (1500 lx) or above under clear weather was about 6-8 h. Area C belongs to the dark area in which light intensity was below 19.22 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (961 lx). The maximum light intensity in area D and E was observed at 8:00 (Table 2). In area D, the illuminated duration was about 2 h; the light intensities of 20-24 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (1000-1200 lx) and 16.40 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (820 lx) in clear weather could last about 4 h, respectively. In area E, the length of the light intensities of 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (6000 lx) and 40 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (2000 lx) in clear weather was about 4 h, respectively. According to the above observation, the light intensity had a significantly difference in the 5 areas. The selected regions represent the indoor environmental condition. The favorite environment conditions for *Muehlewbeckia complera* growth could be found in the indoor environmental condition.

Table 1. Temperature, humidity, and light intensity in 5 experimental areas (April, 2003)

Area	Temperature /°C	Relative humility (%)	Light intensity /$\mu mol \cdot m^{-2} \cdot s^{-1}$
A	16-22	46-60	2.06-946.00 (103-47300 lx)
B	16-22	46-60	1.14-46.80 (57-28401 lx)
C	16-22	46-60	0.16-19.22 (8-960 lx)
D	16-28	44-64	0.64-564.00 (32-28200 lx)
E	16-28	44-64	2.06-128.60 (103-6430 lx)

Table 2. The diurnal changes in light intensity at an interval of 2 hours in 5 areas (April 2003)

Area	Diurnal light intensity /$\mu mol \cdot m^{-2} \cdot s^{-1}$	Light intensity at different hours /$\mu mol \cdot m^{-2} \cdot s^{-1}$				
		at 8:00 a.m.	at 10:00 a.m.	at 12:00 a.m.	at 14:00 p.m.	at 16:00 p.m.
A	2.06-946.00 (103-47300 lx)	2.06-10.00 (103-500 lx)	16.00-52.00 (800-2600 lx)	24.00-92.00 (1200-4600 lx)	32.00-946.00 (1800-47300 lx)	16.00-240.00 (800-12000 lx)
B	1.14-56.80 (57-2840 lx)	1.14-6.00 (57-300 lx)	7.00-36.00 (350-1800 lx)	11.00-38.00 (550-1900 lx)	20.00-56.80 (1000-2840 lx)	8.00-34.00 (400-1700 lx)
C	0.14-19.22 (8-961 lx)	0.14-2.00 (8-100 lx)	0.60-16.00 (30-800 lx)	6.00-17.20 (300-860 lx)	4.00-19.22 (200-961 lx)	1.60-10.00 (80-500 lx)
D	0.64-564.00 (32-28200 lx)	40.00-564.00 (2000-28200 lx)	8.00-24.00 (400-1200 lx)	6.00-20.00 (300-1000 lx)	4.00-16.40 (200-820 lx)	0.64-14.00 (32-700 lx)
E	2.06-128.60 (103-6430 lx)	36.00-128.60 (1800-6430 lx)	24.00-120.00 (1200-6000 lx)	24.00-120.00 (1200-6000 lx)	20.00-40.00 (1000-2000 lx)	2.06-40.00 (103-2000 lx)

Table 3. The increment of leaf number and leaf area of *Muehlewbeckia complera* growing in 5 areas

Item	Area A	Area B	Area C	Area D	Area E
Number of new leaves per branch	6	4	2	3	4
Increment of leaf area per branch (cm^2)	1.12	0.86	0.6	0.76	0.78

Comparison between plant increment and different light intensities

The increment results showed that *M. complera* in area A (2.06-946.00 $\mu mol \cdot m^{-2} \cdot s^{-1}$, 16-22 °C, RH46-60%) had the most growth potential (Table 3). In this area A, the increments of leaf area and leaf counts were the highest (1.12 cm^2 and 6 leafs per branch, respectively). The status of seedlings in area C (0.16-19.22$\mu mol \cdot m^{-2} \cdot s^{-1}$, 16-22 °C, RH 46-60%) was discouraging because the increments of leaf area and leaf count were rather small (0.60 cm^2 and 2 leafs per branch, respectively). Area B belongs to a bright area. In clear weather, the illuminated duration of 30 $\mu mol \cdot m^{-2} \cdot s^{-1}$ was about 6-8 h, and the growth of seedling was moderate. The above result showed that the efficiency for solar energy utilization of *M. complera* was better in

bright areas.

The area order of plant increment was area A>area B>area C, and area E> area D. The area order of the maximum light intensity was area A>area B> area C, and area D >area E (this was because area D belonged to the bright area). In clear weather, the duration of the light intensity of 6000 lx in area D was about 4 h. Thus, the dry matter accumulation and the growth increment of seedlings growing in area D were higher.

The increment of *M. complera* was higher when light intensity was higher and the illuminated duration was longer. This showed that *M. complera* was in favorite of higher light intensity and longer illuminated time. However, when light intensity was low, it could sprout new leaves. This implicated that *M. complera* could endure weaker shade. Therefore, *M. complera* is a plant of sun-adaptation and shade-adaptation.

Photosynthetic characteristics of seedlings under different light intensities

After 40 days, the photosynthesis-light response curves of the seedling were observed. The light compensation point, light saturation point, and the maximum net photosynthesis rate were calculated (Table 4).

Table 4. Light compensation point, light saturation point, and the maximum net photosynthesis rate of seedlings in 5 areas

Area	Light compensation point /μmol·m^{-2}·s^{-1}	Light saturation point /μmol·m^{-2}·s^{-1}	Max. net photosynthesis rate /μmol·m^{-2}·s^{-1}
A	16.41	569	8.07
B	10.84	439	6.75
C	9.26	417	6.34
D	9.48	477	7.58
E	11.87	447	6.75

The results (Table 4) showed that *M. complera* could accumulate dry matter and survive in the light intensity of 0.16-946.00 μmol·m^{-2}·s^{-1} (30-47300 lx, RH44%-64%, 16-28 °C). In area C where the light intensity was 0.16-19.22 μmol·m^{-2}·s^{-1} (8-961 lx), the light compensation point and light saturation point were 9.26 μmol·m^{-2}·s^{-1} and 417.00 μmol·m^{-2}·s^{-1}, respectively. The accumulation of dry matter was the least, and the light intensity was not optimum for the growth of the seedlings. In area A (2.06-946.00 μmol·m^{-2}·s^{-1}), the light compensation point, light saturation point, and the maximum net photosynthesis rate were 16.41μmol·m^{-2}·s^{-1}, 569.00 μmol·m^{-2}·s^{-1}, and 8.07 μmol CO_2 m^{-2}·s^{-1}, respectively. It was shown that the accumulation of dry matter in this situation was high. However, the photosynthesis was inhibited under the light intensity of 569.00-946.00 μmol·m^{-2}·s^{-1} in this area. This indicated that *M. complera* could not tolerate the strong light. Integrating the results from the 5 areas, the light compensation point and light saturation point were 6.26-16.41 μmol·m^{-2}·s^{-1}and 419-569 μmol·m^{-2}·s^{-1}, respectively. Thus, the optimum light intensity range determined was 9.26-569.00 μmol·m^{-2}·s^{-1} (463-28150 lx) for *M. complera* growth.

Conclusions

In the most optimum indoor conditions for human living (relative humidity, 44%-64%, temperature, 16-18 °C), the optimum light intensity for the photosynthesis of *M. complera* was 9.26~569.00 μmol·m^{-2}·s^{-1} (463-28150 lx). *M. complera* belongs to the partial sunshine plant (9.26-569.00μmol·m^{-2}·s^{-1}). This species could tolerate partial shade, too. Under the light intensity of 0.16-19.22 μmol·m^{-2}·s^{-1} (in clear weather, the duration length of light intensity of 10 μmol·m^{-2}·s^{-1} or above was about 6 hours), the plant could sprout new leaves. In the environmental conditions which was suitable for human living, *M. complera* should be lay out within the distance of 3 meters from the easting or westing windows, or lay out within the distance of one meter from the northing window, or lay out beyond the distance of 0.7 m but within the distance of 5.0 m from the southing window.

References

Abrams, M.D. and Kubiske, M.E. 1990. Leaf structural characteristic of 31 hard wood and conifer tree species on Central Wisconsin: Influence of light regime and shade tolerance rank [J]. Ecology Management, **31**: 245-253.

Bai Weilan, Ren Jianwu, Gao Yongwei, *et al.* 1999. Study on the shade tolerance of garden plants [J]. Forest Science and Technology, (2): 12-15. (in Chinese)

Wang Yan.1996. Study on the shade tolerance of main garden plants in Beijing [D]. Dissertation for Doctor's Degree of Beijing Forestry University. (in Chinese)

Wu Weihua. 2003. Plant physiology [M]. Beijing: Academic Press, 167-176. (in Chinese)

Ye Jianqiu. 2001. Flower and gardening [M]. Shanghai: Shanghai Culture Press, 217. (in Chinese)

Yue Hua, Yue Li-ran, Lin Kai-feng.2003. Study on the shade tolerance of three indoors-succulent plants [J]. Northern Horticulture, **4** (151): 40-41. (In Chinese)

Zhang Deshun, Li Xiufen.1997. Analysis of the shade tolerance of 24 garden plants [J]. Shandong Forest Science and Technology, **3**: 27-30. (in Chinese)

Zhang Xuanbing, Song Xiqiang and Wuchunli. 2002. Study on the photosynthetic characters of 3 ornamental foliage plants [J]. Fujian Science & Technology of Tropical Crops, **25**(4): 11-12. (in Chinese)